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6. AUTHOR(S) W.W.L. Au D.L. Herzing				
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13. ABSTRACT (Maximum 200 words) A technique using multi-element arrays of hydrophones with underwater video recording was developed as a tool to accurately measure echolocation signals of free-swimming dolphins. Two configurations of hydrophones, including a line array of three hydrophones spaced at 30 cm and a symmetrical star configuration of four hydrophones spaced at 45.7 cm, were used. The arrays were held by a skin diver while dolphins oriented on the arrays. Video and acoustic signals were cabled back to the boat. A real-time analog/digital data acquisition system operating at 500 kHz was used to detect, digitize, and store echolocation signals. Spotted dolphin echolocation signals had bimodal frequency spectra with frequency peaks at 40-60 kHz, and 120-140 kHz. Peak to peak source levels up to 210 dB re 1 uPa were measured. Bandwidth clustered around 40 kHz. This system was productive as a portable field tool for acquiring and measuring, real-time, echolocation signals of free-ranging dolphins.				
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**REAL-TIME ACQUISITION AND MEASUREMENT OF ECHOLOCATION
SIGNALS EMITTED BY WILD ATLANTIC SPOTTED DOLPHIN, *STENELLA
FRONTALIS*, UTILIZING HYDROPHONE ARRAYS WITH SIMULTANEOUS
UNDERWATER VIDEO.**

W.W.L AU AND D.L. HERZING

ABSTRACT

A technique using multi-element arrays of hydrophones with underwater video recording was developed as a tool to accurately measure echolocation signals of free-swimming dolphins. Two configurations of hydrophones, including a line array of three hydrophones spaced at 30 cm and a symmetrical star configuration of four hydrophones spaced at 45.7 cm, were used. The arrays were held by a skin diver while dolphins oriented on the arrays. Video and acoustic signals were cabled back to the boat. A real-time analog/digital data acquisition system operating at 500 kHz was used to detect, digitize, and store echolocation signals. Spotted dolphin echolocation signals had bimodal frequency spectra with frequency peaks at 40-60 kHz, and 120-140 kHz. Peak to peak source levels up to 210 dB re 1 μ Pa were measured. Bandwidth clustered around 40 kHz. This system was productive as a portable field tool for acquiring and measuring, real-time, echolocation signals of free-ranging dolphins.

FINAL TECHNICAL REPORT:

Grant #: N00014-95-1-1244

PRINCIPAL INVESTIGATORS: - DR. DENISE L. HERZING
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GRANT TITLE: Measurement of Echolocation Signals of Wild
Dolphins Foraging for Bottom and Buried Prey.

REPORTING PERIOD: August 1995 - October 1997

AWARD PERIOD: August 1995 through October 1997

ORIGINAL OBJECTIVE: To record and describe the echolocation signals of free-ranging Atlantic spotted dolphins, *Stenella frontalis*, and bottlenose dolphin, *Tursiops truncatus*, during foraging and other activities.

APPROACH: Multi-element arrays of hydrophones with underwater video recording equipment was developed and deployed in front of echolocating dolphins. Echolocation signals are digitized real-time on-board the research vessel to determine frequency spectra, sound pressure and peak-to-peak source levels, and interclick intervals.

ACCOMPLISHMENTS We have completed 35 days in the field (summer 1996 and 1997). Over 20 files of echolocation click data were collected in 1996, and over 50 files in 1997. Several field days were lost in 1996 due to an impending hurricane. The field array has been deployed and modified to provide optimum operator deployment and retrieval of signals from free-ranging dolphins. Spotted dolphin echolocation clicks had a bimodal spectrum with frequency peaks at 40-60 kHz and 120-140 kHz. Peak-to-peak source levels up to 210 dB re 1 uPa were measured. Bandwidth clustered around 40 kHz.

CONCLUSION: Spotted dolphins appear to have bi-modal signals similar to those of other delphinid species. Source levels were some of the highest recorded for free-ranging animals.

The acquisition and measurement of echolocation signals from free-ranging dolphins provides new information for source levels and frequency spectrum for this species as well as for other species in the wild.

SIGNIFICANCE: The design, development, and successful deployment of portable, high-frequency acquisition equipment expedites the process of recording the echolocation signals of other free-ranging species in the future.

PUBLICATIONS/PRESENTATIONS/ABSTRACTS:

1. Au, W. and D. Herzing. Measurements of the Echolocation Signals Emitted by wild Atlantic spotted dolphin, *Stenella frontalis* in the waters off the Grand Bahamas. Submitted for presentation, Acoustical Society of America, June 1997.

2. Au, W.W.L, Herzing, D.L., Schotten, M., Lammers, M.O. and Aubauer, R. Echolocation Signals of wild dolphins. Biological Sonar Conference. Carboieiro, Portugal 27 May - 2 June 1998.

SEE ATTACHED ABSTRACTS

JASIA-91

ORAL PRESENTATION ONLY

REAL-TIME MEASUREMENT OF THE ECHOLOCATION SIGNALS OF WILD DOLPHINS USING A 4-HYDROPHONE ARRAY

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An array of four hydrophones arranged in a symmetrical star configuration was used to measure the echolocation signals of Atlantic spotted dolphins (*Stenella frontalis*) in the Bahamas. The spacing between the center hydrophone and the other hydrophones was 45.7 cm. A four-channel simultaneous analog-to-digital (A/D) data acquisition system operating at 500 kHz and controlled by a personal computer was used to detect, digitized and store the echolocation signals. A video camera was attached to the array and a video tape recorder time synchronized to the computer. The video camera was used to ascertain the aspect of the dolphins to the array. The array was either suspended from the boat or held by a skin diver and the acoustic and video signals were cabled back to a boat. The echolocation signals had bi-modal frequency spectra with a low-frequency peak between 40-50 kHz and a high-frequency peak between 130-140 kHz. The low-frequency peak dominated when the signal source level (signal amplitude 1 m from the dolphin) was low and the high-frequency peak dominated when the source level was high. The specific frequency of the low and high frequency peaks also depended on the source level. Simultaneous A/D sampling was necessary to determine arrival time differences between hydrophones so that the distance of the echolocating dolphins along with the source levels could be accurately calculated. Peak-to-peak source levels as high as 210 dB were measured. The characteristics of the signals are similar to those of *Tursiops truncatus* and *Pseudorca crassidens* measured in open waters under controlled conditions. The technique of using a multi-element array system along with video recording is an excellent method to accurately measure echolocation signals of free-swimming dolphins.

Measurements of the Echolocation Signals Emitted by Wild Atlantic Spotted Dolphin *Stenella frontalis* in the waters off the Grand Bahamas. Whitlow W. L. Au (Hawaii Institute of Marine Biology, P.O. Box 1106, Kailua, HI 96734) and Denise L. Herzing (Florida Atlantic University, Boca Raton, FL 33431).

A line array of three hydrophones with a video camera attached to the array was used to measure the echolocation signals of wild Atlantic Spotted Dolphins. The separation distance between hydrophones in the array was 30 cm. The array was attached to a float that supported an amplifier-line driver assembly with the signals sent via a 76 m multi-conductor cable back to the support boat. The float and array assembly was oriented by a swimmer. The echolocation signals from the hydrophone were digitized simultaneously at a sample rate of 500 kHz.

Twenty files of echolocation click trains were collected with quality of the data varying from poor (files with lots of whistles and off-axis signals) to very good. The on-axis signals typically had a bimodal spectrum with a low frequency peak at 45-60 kHz and a high frequency peak at 120-140 kHz. Peak-to-peak source levels up to 210 dB re 1 μ Pa were measured. The rms bandwidth varied between 32 and 46 kHz, with a cluster around 40 kHz.

Number of words in abstract: 177

Suggested for special session on Bioacoustic sensing of the environment

Technical Areas: Animal Bioacoustics

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Special facility: VCR player and monitor

Method of presentation: lecture